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Resist Development

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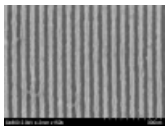
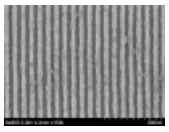
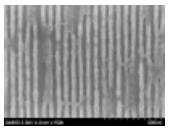
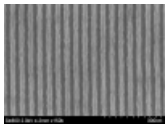
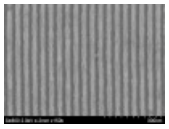
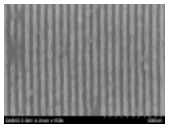
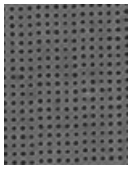
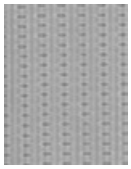
Future generations of computer chips will be manufactured with stringent requirements on three parameters: **Resolution**, **Sensitivity**, and **Line Edge Roughness** (**LER**). All three must be met and balanced, or the chips cannot be made. The following table summarizes the goals for each as laid out in the 2007 ITRS Roadmap:

Year	Resolution	LER	Sensitivity
2013	32-nm half pitch (21-nm iso)	1.2 nm	10 mJ/cm^2
2016	22-nm half pitch (15-nm iso)	0.8 nm	10 mJ/cm^2
2019	16-nm half pitch (11-nm iso)	0.6 nm	10 mJ/cm^2

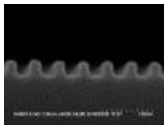
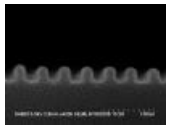
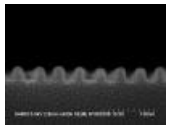
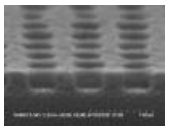
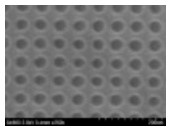
The Berkeley MET tool has been instrumental in improving resists so that resolution is now approaching 20 nm HP using 50 nm thick resists

	24 nm HP	22 nm HP	20 nm HP
Resist C 12.7 mJ/cm^2			
Resist D 15.2 mJ/cm^2			

Contacts have also been printed 30 nm across at a variety of half-pitches

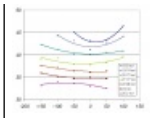
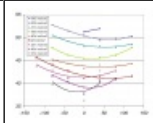
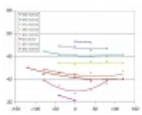
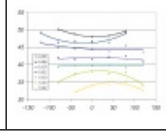
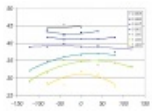
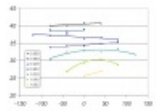
	45 nm HP	40 nm HP	35 nm HP	30 nm HP
1:1				Resist E 80-nm film thickness
1:1.5				

Further demonstrations of high pattern fidelity at small feature sizes

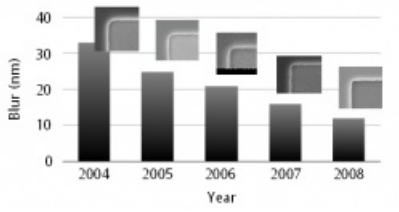
24 nm HP	22 nm HP	20 nm HP
		
30 nm 1:1 contacts		

Line-space resolution: Progress over Time (***Click to see full-size images***)

Year	40 nm Half-pitch	36 nm Half-pitch	32 nm Half-pitch	Annular Illumination

2006				16% 200nm DOF
2007				15% EL 200 nm DOF
2008				8% EL 150 nm DOF

To characterize the performance of resists, systematic contact and corner resist blur metrics have been developed. Steady improvements in resist performance can be seen by comparing these metrics over time:



In contrast to the impressive improvements in resolution, line edge roughness (LER) remains the most difficult challenge facing EUV resists. This can be visualized by comparing LER to sensitivity for various resists to the target of LER < 1.2 nm at 5 mJ/cm^2 on 32 nm dense nodes: